PB85-246692

Comprehensive Indoor Air Quality Research Strategy, January 1, 1985

(U.S.) Interagency Committee on Indoor Air Quality, Washington, DC

Prepared for

Environmental Protection Agency, Washington, DC

Jun 85

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA/600/9-85/021	2.	3. RECIPIENT'S ACCESSION NO. PB85 246692 /AS
4. TITLE AND SUBTITLE COMPREHENSIVE INDOOR AIR QUALITY RESEARCH STRATEGY JANUARY 1, 1985: Interagency Committee on Indoor Air Quality		5. REPORT DATE June 1985 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Michael J. Dellarco, Editor		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Interagency Committee on Indoor Air Quality c/o U.S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460		10. PROGRAM ELEMENT NO. A-109 11. CONTRACT/GRANT NO. NA
12. SPONSORING AGENCY NAME AND ADDRESS Office of Acid Deposition, Environmental Monitoring, and Quality Assurance USEPA, ORD Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE EPA/600/19

15. SUPPLEMENTARY NOTES

Document prepared by participants of the 16 Federal agency Interagency Committee on Indoor Air Quality.

16. ABSTRACT

In the Department of Housing and Urban Development-Independent Agencies 1984 House Appropriation Report, EPA was directed to expand indoor air research planning into a long-term comprehensive strategy. This strategy was developed and coordinated through the Interagency Committee on Indoor Air Quality (CIAQ), a 16 Federal agency committee formed in December 1983.

The aims of this research strategy are to improve the understanding about the risks to indoor air pollutant exposure and to provide technical information and guidance to the public and private sector cost-effectively. These aims will be achieved by completing the following six tasks: identifying indoor air pollutant sources and factors affecting human exposure; characterizing indoor air quality; determining the relationship between energy conservation and indoor air quality; determining the health effects to indoor air pollution; determining optimal control and mitigation techniques; and developing and conducting a national multipollutant field survey. For each of these tasks the status of current Federal research and future research needs are described. An appendix of case studies describes how individual agencies are working together on indoor air quality research.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	34
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB85-246692

EPA/600/9-85/021
June 1985

Comprehensive Indoor Air Quality Research Strategy January 1, 1985

Interagency Committee on Indoor Air Quality

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

i.a

EPA/600/9-85/021
June 1985

COMPREHENSIVE INDOOR AIR QUALITY RESEARCH STRATEGY

January 1, 1985

INTERAGENCY COMMITTEE ON INDOOR AIR QUALITY

Environmental Protection Agency, Co-chair
Department of Energy, Co-chair
Department of Health and Human Services, Co-chair
Consumer Product Safety Commission, Co-chair

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Preface

The strategy which follows, to the maximum extent possible, reflects and is consistent with the programs that are ongoing in various federal departments and agencies. The administration strongly supports the coordination and technical assistance the CIAQ provides to its members and to the public and private sector. However, submission of this report should not be construed as support for a specific long-term separately funded research program. Therefore, no funding levels and timeframes are appropriate and included.

Table of Contents

INTRODUCTION 1

CURRENT FEDERAL RESEARCH 5

TASK #1: DETERMINATION OF INDOOR AIR POLLUTANT SOURCES AND FACTORS AFFECTING HUMAN EXPOSURE 5

TASK #2: CHARACTERIZATION OF INDOOR AIR QUALITY IN THE UNITED STATES 7

TASK #3: DETERMINATION OF THE RELATIONSHIP BETWEEN ENERGY CONSERVATION AND INDOOR AIR QUALITY 9

TASK #4: DETERMINATION OF HEALTH EFFECTS OF INDOOR AIR POLLUTION 11

TASK #5: DEVELOPMENT OF EFFECTIVE CONTROL AND MITIGATION TECHNIQUES 12

TASK #6: NATIONAL MULTIPOLLUTANT FIELD SURVEY 13

COMPREHENSIVE INDOOR AIR QUALITY RESEARCH STRATEGY 15

APPENDIX: CASE STUDIES: RADON AND FORMALDEHYDE 19

REFERENCES 27

INDOOR AIR QUALITY RESEARCH STRATEGY

INTRODUCTION

The effects of air pollution on human health and welfare have been a major concern in this country for decades. Major emphasis has been placed on outdoor sources, outdoor contaminant concentrations, and industrial indoor environments. However, individuals spend as much as 90 percent of their time in indoor environments such as residences, buildings, and various modes of transportation. Studies have established that indoor concentrations of many pollutants can attain levels that exceed outdoor ambient standards, some reaching potentially hazardous levels (1-3). It is becoming increasingly evident that exposure to pollutants indoors may be of considerably greater importance than exposure to pollutants outdoors. In addition, energy conservation measures such as reduction in building ventilation and infiltration rates and use of supplementary heating sources may further elevate concentrations of pollutants indoors.

Many organizations have expressed concerns about indoor air quality including the World Health Organization (WHO) (4), the National Academy of Sciences (NAS) (5), the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) (6), the Office of Technology Assessment (7) and the Consumer Federation of America (8).

In response to the concerns of these groups and Congress (9), sixteen Federal agencies (see Table 1) formed the Interagency Committee on Indoor Air Quality (CIAQ) in December, 1983. One of the first actions of the CIAQ was to form seven workgroups (see Table 2). These workgroups have identified current programs and future needs in indoor air quality research in reports

Table 1: Interagency Committee on Indoor Air Quality (CIAQ) Members

Environmental Protection Agency (EPA)[a]

Department of Energy (DOE)[a]

Department of Health and Human Services (HHS)[a]

Consumer Product Safety Commission (CPSC)[a]

Bonneville Power Administration (BPA)

Department of Defense (DOD)

Federal Trade Commission (FTC)

General Services Administration (GSA)

Department of Housing and Urban Development (HUD)

Department of Justice (DOJ)

National Aeronautics and Space Administration (NASA)

National Bureau of Standards (NBS)

Occupational Safety and Health Administration (OSHA)

Tennessee Valley Authority (TVA)

Department of Transportation (DOT)

U.S. Small Business Administration (SBA)

[a] Co-chair of CIAQ

Table 2: CIAQ Workgroups

Allergens/Pathogens--chaired by NIOSH

Combustion Sources--chaired by CPSC

Field Studies--chaired by NIOSH

Formaldehyde--chaired by CPSC and EPA

Organics--chaired by CPSC and EPA

Radon--chaired by DOE and EPA

Structural Characteristics--chaired by DOE

submitted in June, 1984. These reports are being updated, and will be distributed through the CIAQ by April, 1985.

Congressional interest over the quality of indoor air has been expressed in hearings before the Committee on Science and Technology, U.S. House of Representatives, and in the language of appropriation committee reports in both Houses of Congress requiring coordination between Federal agencies. The most recent examples are the May 23, 1984, Department of Housing and Urban Development-Independent Agencies Appropriation Bill, 1985 Report and the June 28, 1984, Department of the Interior and Related Agencies Appropriation Bill 1985 Report. These reports directed the Environmental Protection Agency to:

> "... expand current planning efforts for indoor air research into a long-term, comprehensive strategy to identify future research needs and priorities. To assure effective coordination with other involved Federal agencies, this strategy should be developed and coordinated through the Interagency Committee on Indoor Air Quality, which EPA chairs. The strategy should be submitted to the Congress by January 1, 1985, and indicate the division of responsibilities among the primary agencies."

and the Department of Energy to:

> "... establish a joint review of the indoor air quality program with (the Environmental Protection Agency and the Consumer Product Safety Commission) to assure a well planned, well coordinated total government effort."

In response to these Congressional concerns, the CIAQ has sought to develop a comprehensive research strategy on indoor air quality. The strategy draws on the varied expertise existing within the public and private sectors to accomplish two aims:

1. To develop an understanding of the magnitude of the risk to human health from exposures to indoor air pollutants and the

contribution of various energy conservation measures, introduction of new building materials and consumer products.

2. To provide technical information and guidance, including cost-effective mitigation measures, to state and local governments, the private sector and the general public.

To accomplish these aims, the following six tasks were identified as critical elements of the strategy. These tasks form the basis of this research strategy, and are interactive. In addition, they are consistent with the recommendations expressed by WHO, NAS, ASHRAE, and others. Accomplishment of these tasks requires an integrated effort by Federal, state, local and private sector researchers.

1. Identification of indoor air pollutant sources and factors affecting human exposure.
2. Characterization of indoor air quality.
3. Determination of the relationship between energy conservation and indoor air quality.
4. Determination of the health effects of indoor air pollution.
5. Determination of optimal control and mitigation techniques.
6. Development and conduct of national multipollutant field studies.

We acknowledge that both the private sector and academics are conducting indoor air quality research. The following discussion describes current Federal research efforts addressing each of these six tasks. This discussion is followed by a section which outlines a comprehensive indoor air quality research strategy. In addition, to determine how the six research tasks integrate into the research strategy, two case studies, for radon and formaldehyde, have been included in an Appendix.

CURRENT FEDERAL RESEARCH

TASK #1: IDENTIFICATION OF INDOOR AIR POLLUTANT SOURCES AND FACTORS AFFECTING HUMAN EXPOSURE

The identification of significant sources of indoor air pollutants (Table 3), their migration pathways and environmental factors that influence human exposure provides the basis for the interpretation of monitoring data and the development of cost-effective control technology. To date, a high priority has been placed on programs that delineate the basic phenomena that affect human exposure primarily for radon, formaldehyde and other organics, and combustion pollutants.

Efforts to determine the sources and dynamics of indoor radon are directed to:

1. Determine the contributions of soil, water, and building materials to the indoor radon source term;
2. Develop models that relate indoor radon concentrations to the various sources, migration pathways, driving forces, and air infiltration rates;
3. Determine environmental factors, such as, building construction, particulate concentrations, temperature, pressure, humidity, and human activity patterns, that influence human exposure to radon and its decay products; and
4. Determine radiation dose to the critical cells of the respiratory tract from the inhalation of radon decay products.

Research on organic pollutants is directed toward determining the contribution of various building materials as chronic sources of airborne

Table 3: Typical Sources of Indoor Air Pollutants

Sources	Pollutants
Ambient Air	Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), Ozone, Carbon Monoxide (CO), Particulates, Organics, Metals
Soil	Radon
Water	Radon, Volatile Organics
Combustion Engines	NO_x, CO, Carbon Dioxide (CO_2), Organics, Particulates, Metals
Building Materials	
Concrete, Stone, Brick	Radon
Pressed wood products	Formaldehyde, Other Volatile Organics
Insulations	Formaldehyde, Fibers, Asbestos[1]
Adhesives, Paints and Solvents	Volatile Organics
Air Conditioners, Humidifiers	Bacteria, Fungi, Protozoa
Combustion Appliances (gas, wood, coal, oil and kerosene)	NO_x, CO, CO_2, Water Vapor, Organics, SO_2, Particulates
Furnishings	Formaldehyde, Other Volatile Organics, Fibers
Office Machines and Supplies	Organics, Particulates
Cleaners and Polishes	Ammonia, Volatile Organics, Particulates
Human	
Metabolic	CO_2, Odors, Water Vapor, Bacteria
Smoking	CO, CO_2, Nitrogen Dioxide (NO_2), Organics, Particulates
Cooking	Organics, Odor, Water Vapor
Hobbies	Organics, Microorganisms
Hygiene	Organics, Odor
Animals and Pests	Microorganisms, Mites, Allergens, (animal dander, insect parts and feces)
Plants, Microbial Contamination	Spores, Pollen, Allergens

[1] Asbestos research is not discussed in this strategy, because Federal research and regulatory action are coordinated through the Federal Asbestos Task Force independent of the CIAQ.

pollutants including formaldehyde. The relationships between pollutant emissions from building materials and building-related factors such as construction techniques, ventilation, temperature, humidity and age of the material are being studied. Consumer product and structural sources of various organic compounds identified indoors are also being evaluated.

Studies are in progress to determine the emission properties and major pollutants of combustion sources such as unvented kerosene and gas heaters and coal/wood stoves. The influences of appliance design, ventilation and use patterns are included in this research.

TASK #2: CHARACTERIZATION OF INDOOR AIR QUALITY

The range and frequency distribution of indoor air pollutant concentrations on a nationwide basis are needed to ascertain the health risks associated with current exposures. Concentrations need to be correlated with many factors including sources, structural characteristics, infiltration and ventilation rates, geography and climate. This information will be used to determine the efficacy of control measures and the impact of energy conservation practices.

Earlier studies which characterized indoor air pollutants were limited in scope because they used small sample sizes, measured only single or few pollutants, studied a single source, were conducted in a limited geographic area or used different methodologies. Though valuable in their context, these data do not provide a unified national picture of indoor air pollution. Therefore, a national multi-pollutant field survey would provide the data base required to develop hypotheses to further test and determine dose-response response relationships. However, before conducting such a study,

there must be an effort to:

1. Develop instruments to monitor pollutants and gather other relevant data;
2. Field test these instruments for efficacy, reliability, and cost-effectiveness;
3. Develop analytical tools and models; and
4. Centralize this information where interested parties can have access to it.

Current Federal research which supports these efforts is described below.

Methods Development

Research to develop passive samplers for carbon monoxide (CO), nitrogen dioxide (NO_2), carbon dioxide (CO_2), volatile organics, water vapor and air exchange rates is in progress. Simple cost-effective active sampling techniques for CO, NO_2, formaldehyde, and organic vapors are being evaluated. Questionnaires to identify pollutant sources and to characterize structural characteristics, weatherization conditions and consumer product usage are being developed. In addition, coordinated efforts are underway to prepare a standard survey design protocol.

Field Monitoring Studies

Both existing and new methodologies are being tested for appropriateness and cost-effectiveness in pilot studies.

Analytical Methods and Models

Mathematical models are being developed to relate indoor pollutant concentrations to pollutant sources, removal mechanisms, thermal comfort parameters, and air exchange rates. These models will be used to predict

indoor air quality and associated health effects in indoor environments, to simulate the effects of proposed mitigation efforts, and to perform cost-benefit analyses. The models will be validated and verified by field data.

IAQ Data Bases

To maximize analysis and distribution of information to interested Federal and local agencies and the private sector, uniform data are needed. Results from past field studies are being compiled for entry into a single data base. Results from current and future field studies will also be entered into this data base.

TASK #3: DETERMINATION OF THE RELATIONSHIP BETWEEN ENERGY CONSERVATION AND INDOOR AIR QUALITY

Potentially adverse indoor contaminant levels are further elevated by efforts to conserve energy. These efforts include reduction of building infiltration and ventilation rates, use of supplemental heating appliances, and introduction of certain building materials. Energy conservation and indoor air quality requirements will have important ramifications on the cost, design and operation of comfort conditioning systems, energy use patterns and peak energy usage.

The growing trend in new construction is substantially reduced infiltration. The state of the art is such that typical levels of about 0.7-1.0 air changes per hour may be reduced to 0.2 air changes per hour. When infiltration is reduced to this extent, elevated levels of indoor pollutants may be found. More research is required to relate ventilation rates to

indoor air pollutant concentrations and to provide for the establishment of energy efficient ventilation guidelines which maintain acceptable indoor air quality.

Infiltration and Ventilation

Research efforts devoted to infiltration and ventilation studies in residential buildings have contributed significantly to the development of infiltration measurement techniques, air leakage characterization of buildings, and infiltration modeling to assess the impact of reduced infiltration rates on energy requirements and indoor air quality. Current research includes:

1. Extending single chamber, residential infiltration models to include all forms of ventilation (both natural and mechanical);
2. Developing and validating low cost methods of measuring infiltration and leakage, e.g., perfluorocarbon tracer gases and acoustic AC pressurization;
3. Testing a multi-chamber infiltration model suitable for multi-family residential buildings and multizone single-family buildings; and
4. Participating in national and international efforts to develop ventilation, leakage, infiltration, and construction quality guidelines.

Only very limited information exists on infiltration and ventilation in commercial and institutional buildings. Research is required to develop and validate techniques to measure ventilation rates and air distribution patterns. Prototype systems are being developed which utilize multiple tracer gases, both actively and passively. Research efforts will test and validate these systems. Data on ventilation rates and efficiencies are

being collected in a number of commercial buildings and will be used to extend the multichamber infiltration model described above.

Combustion Appliances and Building Materials

Research on supplemental heating appliances has included field studies, laboratory chamber studies of pollutant emission rates, consumer use surveys and limited exposure modeling. Current efforts concentrate on development of certification test methods and voluntary guidelines for these appliances.

Formaldehyde emissions from urea-formaldehyde foam insulation, pressed wood products and fibrous glass insulation have been characterized and evaluated. This information has been provided to manufacturers and to consumers for their consideration in development of voluntary guidelines. In addition, volatile organic emissions from building materials, such as sealants and caulking compounds, are now an area of investigation.

TASK #4: DETERMINATION OF HEALTH EFFECTS OF INDOOR AIR POLLUTION

The causal relationship between indoor pollution exposures and adverse health effects is critical to the understanding of population risk. This relationship is needed to evaluate the impact of energy conservation and mitigation strategies. Occupational and residential studies of most indoor pollutants have not produced adequate data to determine specific health effects and exposure-response relationships for pollutants found in indoor air. Only limited data are available to define the acute and chronic health effects from low level exposure to essentially all of the indoor air pollutants. Generally, such effects are extrapolated either from occupational exposure studies or from animal toxicity studies. Animal toxicology studies are in progress on some indoor air pollutants e.g., perchloroethylene, dichloromethane, formaldehyde, and nitrogen dioxide.

Controlled human exposure studies have been initiated to obtain exposure-response relationships for specific acute health effects from exposure to pollutants. Such studies include responses of sensitive individuals (e.g., asthmatics) to exposure to irritant gases such as nitrogen dioxide, formaldehyde, and sulfur dioxide. Additional studies have been initiated to develop biochemical markers of exposure to specific pollutants and pollutant sources. These markers may prove useful in future epidemiological studies.

Health hazard evaluations are documenting exposures to low levels of numerous air contaminants, such as volatile organics. Incidents of adverse health effects are also being reported in commercial and institutional buildings from exposure to volatile organics, sidestream tobacco smoke, fibers, biologically active aerosols, and allergens. Occupational exposure studies have provided some evidence for human health effects from pollutants such as radon and formaldehyde. Additional studies in progress may provide further information on such associations.

Discussions are underway with the National Center for Health Statistics (NCHS) on utilizing the National Health and Nutrition Evaluation Survey III (NHANES III) to determine adverse health effects associated with exposure to indoor air pollutants.

TASK #5: DEVELOPMENT OF EFFECTIVE CONTROL AND MITIGATION TECHNIQUES

As in the case of outdoor pollution, the identification of indoor pollution sources and the development of source control and mitigation strategies will reduce exposures to elevated indoor pollutant concentrations. Control strategies include source control, ventilation, air purification, and architectural and materials applications.

Mitigation and control research is being developed for commercialization of energy efficient techniques to control indoor pollutant concentrations. Current efforts include evaluating techniques to reduce pollutant strengths and block migration pathways, examining pollutant-specific removal mechanisms, and studying ventilation processes in indoor environments.

Ventilation strategies, with and without heat recovery, air purification devices, and architectural and material applications are appropriate in some situations, especially when source control is impractical. The effectiveness of these mitigation measures is being laboratory tested, evaluated, and mathematically modeled.

Pilot mitigation programs are being developed to test a range of approaches for reducing excessive concentrations. The objective of these studies is to assure the effectiveness of mitigation measures in wide-scale mitigation programs. Mitigation measures are being studied as a function of building characteristics, appliances used, and occupant use patterns.

The results of control and mitigation research efforts will be used to develop consensus testing protocols, guidelines, and information for developing voluntary standards, primarily by industry itself. Pilot mitigation program results will be made available in reports to state and local agencies, utilities, and other groups interested in mitigation.

TASK #6: NATIONAL MULTIPOLLUTANT FIELD SURVEY

A large national multipollutant field survey of indoor air pollution will be a key component in the CIAQ research program. The National Multipollutant Field Survey will provide the data base required to develop hypotheses to determine dose-response relationships. The survey will draw upon the results of the previous research tasks, and the survey results

will focus future research in these ongoing efforts. The survey will provide an estimate of the range and distribution of indoor exposures to indoor air pollutants, and identify those factors which influence their concentrations. The impact of energy conservation practices, including reduced ventilation rates and use of supplementary heating sources, and the effectiveness of mitigation techniques will be studied. A National Multi-pollutant Field Survey is necessary to identify and focus indoor air quality research efforts, to control indoor air pollution and to assess the impact of future energy conservation.

The best approach to obtain health effects data related to indoor air quality is being explored. Information on health effects may be obtained from health studies of specific pollutants, including groups with high exposures to indoor air pollutants. Selected health effects information could be collected as part of the national survey. One approach to obtaining health effects data is to conduct an indoor exposure study in conjunction with another health study such as the NHANES study planned for Fiscal Year 1988 by NCHS.

The CIAQ has directed its Field Studies Workgroup to direct the planning, development and execution of this national survey. Over the next year, this Workgroup will coordinate the development of sample design options for a national survey, taking into account the research on factors affecting exposure levels of specific indoor air pollutants (e.g., climate, pollutant sources, ventilation). The Workgroup will also evaluate and coordinate the CIAQ agencies' research efforts in field testing and participation in regional indoor air quality studies. These coordination efforts will help

ensure that this Federal research effort will provide the necessary basis for conducting a national field survey.

In a similar fashion, the Field Studies Workgroup will review current health studies, and recommend various options for obtaining health effects information, including a possible joint survey in conjunction with the NCHS NHANES III study.

By the end of FY 1985, the Workgroup will present various options for a national indoor air field survey to the full CIAQ for review and implementation.

COMPREHENSIVE INDOOR AIR QUALITY RESEARCH STRATEGY

Current Federally sponsored research is addressing, in a limited way, each of the six previously identified tasks. Because of the nature of the indoor air pollution problem, a much more comprehensive program is required by both the public and private sectors. The following strategy is directed at overall program needs, with the CIAQ and its workgroups providing a central coordinating function in the development process. Federal agencies will collaborate in the development and accomplishment of this program according to their missions, expertise, and budgetary capacity.

Each of the six research tasks discussed previously is essential to the definition of current and future trends in indoor pollutant exposure, the consequent risk, and the most effective mitigation techniques. In addition to the current research tasks described in the previous sections, the following research needs must also be pursued.

Task #1: SOURCES AND ENVIRONMENTAL FACTORS AFFECTING HUMAN EXPOSURE

- Initiate research efforts to identify and quantify sources of indoor allergens and organic compounds
- Expand efforts to quantify sources and pathways of combustion products, radon, and formaldehyde

- Investigate environmental factors (e.g., air exchange rates, structural characteristics) affecting occupant exposures to indoor air pollutants

Task #2: CHARACTERIZATION OF INDOOR AIR QUALITY

- Methods Development and Field Testing

  Develop monitoring instrumentation, both active and passive, for volatile organic pollutants, allergens, microorganisms, particulates, and NO_2

  Refine, field test, and transfer to the commercial market instrumentation for CO and all of the above

  Develop survey questionnaires and protocols

- Quality Assurance

  Develop quality assurance programs similar to that in place for radon for the important chemical and biological pollutants, to assure that exposure measurements made by various laboratories in the United States and elsewhere are comparable

- Analytical Methods and Modeling

  Develop standardized techniques for data analysis that assure validity and accuracy

  Improve and validate existing multipollutant indoor air quality models

- Data Base

  Expand data bases to include measurement technologies and health effect surveys

Task #3: IMPACT OF ENERGY CONSERVATION

- Develop predictive models for determining the effects of building design and energy conservation practices on future indoor pollution exposures

- Refine passive samplers for multi-zonal infiltration and ventilation studies

- Develop techniques to perform air infiltration, ventilation, and ventilation efficiency measurements in commercial and institutional buildings

Task #4: HEALTH EFFECTS

- Conduct chronic toxicity studies in laboratory animals
- Study populations particularly sensitive to chemical or microbial indoor air pollutants
- Develop biochemical markers for exposure to pollutants e.g., urinary cotinine for passive tobacco smoke and urinary hydroxylproline for NO_2
- Evaluate the toxicity of low level exposure to particulates and other chemicals both individually and in combinations
- Develop and conduct appropriate epidemiological studies for indoor pollutants, e.g., radon and formaldehyde
- Utilize more sophisticated approaches to study the health effects of pollutants such as NO_2, CO and formaldehyde
- Evaluate the use of CO_2 in large buildings to predict complaints of tight building/sick building syndrome

Task #5: POLLUTANT CONTROL

- Develop and evaluate source control and mitigation measures for risk reduction and cost effectiveness for a broad range of indoor environments and pollutants
- Validate minimum ventilation requirements to support consensus guidelines designed to provide acceptable health and comfort levels in indoor environments

Task #6: NATIONAL MULTIPOLLUTANT SURVEY

- Develop and conduct a multipollutant field survey to determine the national distribution of indoor exposures and associated health effects
- Utilize survey results to design and conduct specific studies to obtain additional information about health effects, energy conservation, pollutant sources and control options

In summary, a major national effort is needed to implement this comprehensive indoor air quality research strategy. Action is needed by both the public and private sectors. The CIAQ's role in addressing this problem will be to coordinate Federal research efforts, and to develop new mechanisms for

interacting with state and local governments and the public and private sectors. Through the CIAQ workgroups, research conducted in other programs, such as the National Toxicity Program, will be used to augment indoor air quality efforts. The CIAQ will also periodically evaluate research results to reassess health risks associated with indoor air pollution. Finally, the CIAQ will make a concerted effort to assure technology transfer through dissemination of research results and participation in symposia, public meetings, and workshops.

Appendix A

Case Studies: Radon and Formaldehyde

The case studies which follow demonstrate how these six tasks delineated in the strategy are being pursued for both radon and formaldehyde.

Radon:

The inhalation of the decay products of radon is likely to be one of the most significant sources of risk to human health from indoor air pollution, contributing to approximately 5,000 to 15,000 lung cancer cases per year (10). Expertise in radon research has been developed in DOE, EPA, and HHS programs in response to recognized problems in uranium, phosphate and radium industrial activities. In recent years, increased attention has been given by DOE, EPA, HUD, NBS, TVA, and BPA to the overall problems associated with environmental radon exposure, both outdoor and indoor. Coordination of these research efforts has been achieved through the ad-hoc Interagency Research Group on Indoor Air Quality and, since 1983, the Radon Working Group of the Committee on Indoor Air Quality. As a consequence of this work, the capability of assessing the health risks associated with current and possible future exposures of the U.S. population to radon is more advanced than for any other indoor air pollutant.

The research progress to date can be related to the six tasks of this strategy document in the following way:

Task #1 Sources and Influence of Environmental Factors

This identification of sources of indoor radon and the influence of environmental factors on radon concentrations has been a main thrust of

Federally sponsored research. DOE, EPA, and TVA sponsored research programs have established the existence and relative importance of soil, water and building materials as radon sources. In the United States, soil is usually the dominant source. DOE research has identified pressure differentials and convective processes as the mechanisms for driving most of the radon into structures. EPA and DOE research groups are cooperatively developing models of environmental and structural factors influencing radon and decay product exposures.

Task #2 Characterization of Exposure

Major efforts have been made to develop and evaluate techniques for the measurement of radon and its decay products. Methods are now available, many commercially, for both active and passive measurements. DOE, EPA, Bureau of Mines (BOM), NBS, state agencies, academia, and the private sector have cooperated in the conduct of intercomparisons of measurement instruments and techniques. The DOE Environmental Measurements Laboratory and the BOM Denver Research Center are two of the four reference laboratories in an international intercalibration program being sponsored by the Organization of Economic Cooperation and Development (OECD) Nuclear Energy Agency.

Exposure data obtained in limited Federally sponsored field studies constitute a significant fraction of the overall data base on indoor radon exposure in the United States. The available data are currently being used to initially assess the frequency distribution of radon exposure. They suggest that the inhabitants of perhaps a million homes in the United States are exposed to radon levels in excess of the current recommendation for remedial action of the National Council on Radiation Protection and Measurements (11).

Task #3 Energy Conservation

The effect of energy conservation practices on radon exposure is related primarily to those conservation measures which reduce air exchange rates. DOE, BPA, and TVA have conducted field studies of radon exposure which have included investigations of exposure before and after retrofitting and in energy-efficient structures.

Task #4 Health Effects

Extensive studies of radon exposure and accompanying health effects in selected populations of mine workers have been sponsored by HHS, BOM, EPA, and DOE, and groups in other countries. These studies have established a clear association of radon exposure with the incidence of lung cancer in miners. Models have been developed which extrapolate these results to individuals in normal environmental situations. These developments form the basis for the non-occupational risk estimates used by the various Federal agencies. Case-control epidemiological studies in the environmental situation must be conducted to reduce the uncertainties in these risk estimates. For example, an important element of future studies would be establishing the possible relationship between radon exposure and smoking in the induction and promotion of lung cancer.

Task #5 Control and Mitigation

Radon source control and mitigation research is being conducted to develop both retrofit techniques for existing structures and improvements in construction practices for new housing. Mitigation methods, such as air-to-heat exchangers, use of sealants, and mechanical ventilation of substructure spaces, are being evaluated. New EPA and DOE research initiatives are

being directed at controlling radon sources. Practical retrofit techniques are likely to be available in the near future. Future studies will emphasize the control of radon entry through revised building design and construction practices.

Task #6 National Multipollutant Survey

The National Multipollutant Survey now being considered will include a radon component. In addition, the CIAQ is also considering a separate national radon survey which could be started and completed much sooner, since radon sampling protocols are currently available. The product of these survey efforts will be the national frequency distribution of radon exposure and information on factors that influence this distribution. This information is of interest to agencies such as EPA and HUD as means to identify structures that have, or are likely to have, unusually high radon levels. This distribution is also valuable to DOE, TVA and BPA in the assessment of future trends in exposure due to the introduction of advanced conservation technology. These Federal agency interests are considered in decisions to assist state and local agencies with their indoor pollutant field studies.

The CIAQ Radon Working Group will provide a mechanism for updating the inventory of Federal radon research and evaluating research priorities, thereby determining the role of the various agencies in Federal radon research.

Formaldehyde:

Formaldehyde is a highly irritating gas which has caused cancer in animals. Indoor concentrations are generally much higher than outdoors. Low level acute exposures as encountered in indoor air have resulted in eye, nose and throat irritation, while long-term exposures have been associated with health problems such as headaches, dizziness, nausea, coughing, recurring infections of upper respiratory tract and menstrual irregularities. Formaldehyde is also a sensitizer at least via the dermal route. There are human studies that suggest that formaldehyde exposures may be associated with genotoxic changes in the blood and cancers of skin, brain, blood (leukemia), pharynx, larynx, and lung.

The major sources of formaldehyde indoors are generally pressed wood products, insulations and combustion. Other sources include textiles, furnishings, and consumer products. CPSC, EPA, HUD, DOE, industrial organizations, and academia have developed expertise and are working to define the overall problems associated with formaldehyde exposure. Coordination of research efforts have been carried out through the Interagency Regulatory Liaison Group (IRLG), Ad-hoc Interagency Research Group on Indoor Air Quality, CPSC liaison with government agencies and industry, and more recently thorugh the formaldehyde workgroups of the CIAQ and the Interagency Risk Management Council (IRMC). As a result, the capability of assessing risks from formaldehyde exposure is more advanced than any other chemical indoor pollutant.

The research progress to date can be related to the six tasks of this strategy document in the following way:

Task #1 Sources and Influence of Environmental Factors

CPSC, DOE, EPA, HUD, TVA, and industrial groups have identified the importance of source strength, emission rates, background concentrations, decay rates and environmental factors on indoor formaldehyde levels.

Task #2 Characterization of Exposure

The efforts of CPSC, DOE, EPA and the private sector have resulted in development of commercially available active and passive formaldehyde monitors. Limited intercomparisons of instruments and techniques have been conducted by CPSC, DOE, EPA and the private sector. More studies are in progress. The multiple factors influencing indoor formaldehyde levels are being incorporated into predictive models. The CPSC, DOE, EPA, TVA, various State Departments of Health, and the private sector have conducted small scale field studies to obtain exposure data. The results from these studies, even though obtained with differing methodologies, constitute the major portion of available exposure data, and indicate a significant portion of the U.S. population may be exposed to elevated levels of formaldehyde.

Task #3 Energy Conservation

The effects of reduced ventilation rates and use of supplementary heating sources on indoor formaldehyde emission rates and concentrations have not been extensively investigated. Limited data suggest that formaldehyde concentrations may not be inversely proportional to changes in air exchange rates.

Task #4 Health Effects

Health effects data on formaldehyde were generated and compiled through the efforts of CPSC, EPA, NIOSH, National Cancer Institute, academia, industry, and similar institutions in Europe. A consensus regarding the adverse health effects from low-level exposure to formaldehyde was agreed to at a conference sponsored by the White House Office of Science and Technology Policy (OSTP) (12). The use of data and models for estimation of cancer risk from exposure to formaldehyde is being coordinated through the Interagency Risk Management Council (IRMC). The Formaldehyde Workgroup of the CIAQ will continue to inventory, evaluate, and distribute the results of health-related research.

Task #5 Control and Mitigation

Early steps toward defining the appropriate control and mitigation techniques were taken by CPSC, Canadian Department of Consumer Protection and the private sector. However, more extensive efforts await the understanding of sources and factors that influence indoor concentrations.

Task #6 National Multipollutant Survey

The National Multipollutant Survey now being planned will include a formaldehyde monitoring component. Once an inter-laboratory comparison of commercially available methods is completed, the CIAQ may consider a separate national radon and formaldehyde survey. The national frequency distribution of formaldehyde exposure coupled with probable sources and building structural characteristics is necessary to identify populations at risk, define control and mitigation measures, and assess the impact of future trends in energy conservation.

The Formaldehyde Workgroup of the CIAQ will continue to provide a mechanism for compiling formaldehyde research, evaluating overall research priorities, and performing peer reviews of a) proposed projects, b) data from completed studies, and c) documents generated by Federal agencies. As a consequence, the workgroup will define for the CIAQ the role of various agencies in Federal formaldehyde research.

REFERENCES

1. Government Accounting Office, Indoor Pollution: An Emerging Public Health Problem (Government Printing Office, Washington, D.C., 1980).

2. "Symposium on health aspects of indoor air pollution," Bull. N.Y. Acad. Med. 57 (1981)

3. "Proceedings of the 3rd International Conference on Indoor Air Quality and Climate," (Swedish Council for Building Research, Stockholm, Sweden, 1984).

4. Health Aspects Related to Indoor Air Quality (World Health Organization, Geneva, 1979).

5. Committee on Indoor Pollutants, National Research Council, Indoor Pollutants (National Academy Press, Washington, D.C., 1981).

6. The American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc., "Position statement on indoor air quality," approved by the ASHRAE board of directors on July 1, 1981.

7. Office of Technology and Assessment, Residential Energy Conservation (Government Printing Office, Washington, D.C., 1979).

8. Consumer Federation of America, "Policy Resolutions 1985", in preparation.

9. House of Representatives, 90th Congress, 1st Session, H.R. 2899, Report No. 98-212, Part I, referred to the Committee on Appropriations on May 16, 1983.

10. National Council on Radiation Protection, Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States, Report No. 78, May 31, 1984.

11. A.V.J. Nero, Lawrence Berkely Laboratory Publication, LBL-10525 (August 1981).

12. Office of Science and Technology Policy, Report on the Consensus Workshop on Formaldehyde (Little Rock, Ar., October 3-6, 1983).